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Changes in Liquidity,Cash Market Activity, and Futures Market Performance:Evidence from Live Cattle Market in Brazil

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This paper describes developments in the Brazilian live cattle market in the last decade, which resulted in an almost tenfold increase in futures trading, and investigates their effects on futures market's price discovery and risk transfer functions. Higher trading volume appears to have modestly reinforced the long-run relationship between spot and futures markets, strengthened the role of futures market in the pricing process, and led to a more rapid transmission of market information between spot and futures markets. In terms of risk transfer, the results provide little evidence that the live cattle futures contract offers effective hedging opportunities, either under low or high trading volume. The findings are consistent with previous studies in the sense that even low trading volume is enough to establish links between spot and futures markets. However, the absence of hedging opportunities when futures trading increases was somewhat surprising and raises questions for future research.

Keywords: futures market, price discovery, hedging

INTRODUCTION

Concerns over behavior, performance, and ultimate survival often emerge in markets that are thinly traded. Low trading volume is often related to a relatively small amount and low quality of information in both cash and futures markets (Tomek, 1980; Carter, 1989). In futures markets, limited liquidity and low quality ofinformation can lead to market inefficiency, poor price discovery, and reduced risk management capability. Studies of failed contracts often point to limited liquidity and the inability of contracts to provide effective hedging opportunities for commercial firms (e.g., Thompson et al. 1996).Furthermore, well-functioning cash markets and strong participation of hedgers have also been identified as major factors for the development and survival of futures markets.In a developing context, Williams et al. (1998) discuss the evolution of the mungbean futures market in China. They report strong increase in trading volume and indicate that part of this expansion was due to growing participation of commercial firms in the futures market. However, the subsequent failure of the contract calls into question the importance of the magnitude of trading in futures alone in the absence of a well-established cash market. Wang and Ke (2005) investigate futures market in China and find evidence of efficiency for soybeans but not for wheat, which is likely related to the fact that wheat cash market is more heavily regulated by the government than soybeans. Recent empirical studies also generally support the notion that growing liquidity in emerging markets tends to stimulate arbitrage and hence improve market efficiency (Chordia et al. 2008; Chung and Hrazdil 2010).

The purpose of this paper is to investigate how changes in the live cattle cash market in Brazil have influenced the growing trading volume in its futures contract, and to assessthe impact on price discovery and risk transfer.Until the early 2000s the live cattle futures market in Brazil was thinly traded and hedgers had a relatively low participation. Using data through 2003, Mattos and Garcia (2006) study price discovery and risk transfer in three thinly traded futures contracts in Brazil (coffee, live cattle and sugar), and find evidence of liquidity thresholds needed for futures market to perform its functions. Futures markets in a general sense appeared to facilitate price discovery even when trading volume was insufficient to guarantee systematic hedging opportunities.Specifically, the live cattle market was characterized by low trading volume, poor hedging effectiveness, but similar stochastic trends for cash and futures prices. Similar to the work in a spatial context (McNewand Fackler, 1997), they conclude that the presence of similar stochastic patterns does not necessarily imply trading opportunities and arbitrage between markets.

Since that time the Brazilian live cattle market has changed rather dramatically, including an almost tenfold increase in annual trading volume in the Brazilian live cattle futures market. In 2000-2003 an average of 513 futures contracts were traded daily,while in 2008-2010 an average of 4,426 contracts were traded daily. Urso (2007) discusses the structure and changes in the live cattle market over the last 10 years. Brazilian meat packers have greatly increased exports, which motivated them to adopt forward and futures contracts more actively. Mergers and acquisitions among meat packers have also occurred, creating fewer and larger companies with more complex and sophisticated financial structures. In addition to generate capital, some packers have “gone public” with their stock, requiring them to be more financially accountable and transparent.

The live cattle futures market in Brazil offers a unique opportunity to study the interaction of cash market expansion, commercial firms’ development, growing futures trading, market efficiency, and price discovery and risk transfer effectiveness.It is believed this study will provide useful findings on how changes in cash market affect trading in futures markets and how market performance can improve due to increasing liquidity. In particular, government agencies in developing countries may benefit from a better understanding of the importance of the relationship between cash and futures marketswhen considering the implementation and usefulness of futures markets to improve risk management. Similarly, the nature of market participants and specifics in design and implementation of contracts and policies may all emerge as crucial for effective contract performance. Our results can also be relevant for industry which might be able to gather new insights that could shed light on challenges currently facing futures markets.

BACKGROUND

The structure and changes in the live cattle market in the last 10 years are discussed by Urso (2007). Brazilian meat packers have greatly increased exports over the last decade, which turned Brazil into the largest beef exporter in the world. In the late 90’s Brazilian exports were around 0.4 million tons per year. In the early 2000’s several factors motivated meat packers to increase their exports, including favorable exchange rate and rising competition with other types of meat in the Brazilian market. Beef exports increased during the 2000’s and reached 2.5 million tons in 2008, showing a fivefold expansion compared to the beginning of the decade (Appendix, Figure 1).

Meat packers typically sign export contracts 4-6 months prior to the actual trade (Urso, 2007). Price in US$ is determined when the contract is signed, so the selling price is locked in but packers are still exposed to risk in exchange rate and in the purchase price they must pay to cattle producers. In this environment packers started to use forward contracts with producers more intensively to manage price risk in the domestic market and to offer producers a guaranteed price to secure supply. In this context, packers then hedge their transactions with producers by taking short positions in the live cattle futures market. Packers have essentially developed an instrument to provide risk management to producers (who historically made little use of futures markets), taking the place of producers as the futures hedgers in the beef industry.

This new activity has contributed to their rising participation in futures markets and increased trading volume. In 2000-2003 an average of 513 futures contracts were traded daily. In 2008-2010 an average of 4,426 contracts were traded daily, reaching peaks of over 20,000 contracts traded in a single day (Appendix, Figure 2).Sellers in the live cattle futures market have always been meat packers and cattle producers, who account for approximately 90% of short open interest positions. However, the change in packer behavior over the last decade has changed the relative share of short positions. In 2000-2001 cattle producers were about 80% of all short open positions in the market, while packers were approximately 10%. By 2010 packers accounted for about 75% of short open interest, while producers accounted for about 10% (Appendix, Figure 3).

In addition, mergers and acquisitions among meat packers have occurred, creating fewer and larger companies with more complex and sophisticated financial structures. Three large meat packers opened their stock to the public: JBS-Friboi on March 29th 2007, Marfrig on June 28th 2007, and Minerva on July 20th 2007. These three packers are among the four largest packers in Brazil, and account for nearly 50% of Brazilian exports. Since they now have stocks traded in the open market, the need for financially accountability and transparency increases. Pennings and Leuthold (2000), Pennings and Garcia (2004), and Pennings and Wansink (2004) discuss the importance of managerial and financial aspects of firms in their risk management decisions.

Finally, the rising need to hedge in futures market attracted speculators. Speculators were also attracted by the delivery rules in the live cattle futures contracts, which specify that physical delivery can only occur when sellers want to deliver and also buyers want to take delivery.If speculators are on the long side of the futures market, they do not have to take delivery if they do not want to. If buyers are not interested in taking delivery, futures contracts are liquidated by cash settlement based on a 5-day average of a spot price fromthe four spot markets in the state of São Paulo.

REVIEW OF LITERATURE

The literature on price discovery and risk transfer is extensive, and the discussion here will focus on selected studies that illustrate general findings for agricultural markets. Mattos and Garcia (2006) study price discovery and risk transfer in three thinly traded futures contracts in Brazil (coffee, sugar, and live cattle). They find evidence of liquidity thresholds needed for futures market to perform its functions. Futures markets in a general sense appeared to facilitate price discovery even when trading volume was insufficient to guarantee systematic hedging opportunities. Specifically, they investigate the live cattle market using data from 2001 to 2003, and their findings indicate the market was characterized by low trading volume (daily average trading volume was 481 contracts), poor hedging effectiveness, but similar stochastic trends for cash and futures prices. Results show that cash and futures markets were cointegrated, but only the cash pricewould make the adjustment to deviations from the long-run equilibrium. Still, cash and futures prices interact in the short-run. In terms of risk transfer, estimated hedge ratio was 0.07 and hedging effectiveness was 0.03, suggesting poor hedging opportunities.

Results from Mattos and Garcia (2006) are generally in line with other studies investigating price discovery and risk transfer in agricultural futures markets. Brockman and Tse (1995) investigate the price discovery mechanism in four thinly-traded agricultural commodities markets in Canada (canola, barley, oats, and wheat). Using daily prices between 1978 and 1994, spot and futures prices are found to be cointegrated for all markets. Further they find the error correction term is always statistically significant when the change in spot price is the dependent variable, but generally not statistically significant when the change in futures price is the dependent variable. Similar to Mattos and Garcia (2006), this finding suggests that spot and futures prices share a long-run relationship, but only spot prices tend to make the adjustment to deviations from the long-run equilibrium.

Fortenberry and Zapata (1997) evaluate price linkages between futures and cash markets for cheddar cheese, diammonium phosphate (DAP) and anhydrous ammonia (NH3). In all three markets, they focused on the period immediately after the contracts were launched. Based on cointegration procedures, they find no evidence that futures and spot prices of cheddar cheese shared a long-run relationship, but do find the presence of cointegration for the DAP and NH3 markets even when examining only the first year of trading. These findings suggest that even newly formed and thinly traded futures markets can be effective price discovery mechanisms. With respect to the cheddar cheese market, Thraen (1999) re-examines the existence of cointegration between its cash and futures prices using a longer time series.[1] In contrast to Fortenberry and Zapata (1997), Thraen (1999) finds a long-run relationship between cash and futures prices, suggesting that the equilibrium relationship emerged with more extensive trading.

Yang et al. (2001) examine the price discovery performance of futures markets and its relationship with asset storability using daily data from 1992 to 1998. They select storable (corn, oats, soybean, wheat, cotton, and pork bellies) and non-storable (hogs, live cattle, feeder cattle) commodities in their sample. Based on cointegration procedures and error correction models, their results support the notion that futures markets can be used as an effective price discovery tool, and showed that asset storability does not affect the price discovery. Although they didn’t distinguish between thinly and heavily traded markets, the large differences in trading activity of the markets analyzed in their study suggests that it had little effect in the price discovery mechanisms.

RESEARCH METHOD

Price discovery and risk transfer between futures and cash markets are investigated using cointegration procedures. When cash and futures prices are cointegrated, their relationship can be represented by the error-correction model given by (1) and (2):

[1]Fortenberry and Zapata (1997) used weekly data from June 1993 to July 1995, and Thraen (1999) used weekly data from July 1993 to October 1997.

$$\Delta F_t = \alpha + \Pi \cdot z_{t-1} + \sum_{i=1}^{q} \beta_i \Delta F_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta C_{t-j} + \varepsilon_t \qquad (1)$$

$$\Delta C_t = \alpha' + \Pi' \cdot z_{t-1} + \sum_{i=1}^{q} \beta_i' \Delta F_{t-i} + \sum_{j=1}^{q} \gamma_j' \Delta C_{t-j} + \varepsilon_t' \qquad (2)$$

where ΔF_t and ΔC_t are first differences of futures and cash prices, and z_{t-1} reflects the lagged deviation from equilibrium generated by the cointegration vector. The Breusch-Pagan and ARCH-LM tests for heteroskedasticity are performed, and GARCH and White's procedures are used in the presence of a non-constant variance in the residuals.

In order to assess price discovery, Wald tests are applied on estimated coefficients. The overall null hypotheses of non-causality $H_0 : \Pi = \gamma_1 = ... = \gamma_q = 0$ in equation (1) and $H_0 : \Pi' = \beta_1' = ... = \beta_q' = 0$ in equation (2) assess the long-run and short-run dimensions of the market interactions. Tests on Π s indicate whether markets adjust to disequilibrium, while tests on the $\beta's$ and $\gamma's$ provide insight into the short-run interaction between markets.

Risk transfer is examined by assessing hedging performance in an error-correction framework. In the presence of cointegration, a hedge ratio ϕ is obtained by estimating equation (3).

$$\Delta C_t = \alpha + \Pi \cdot z_{t-1} + \phi \cdot \Delta F_t + \sum_{i=1}^{q} \beta_i \Delta F_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta C_{t-j} + \varepsilon_t \quad . \qquad (3)$$

Hedging effectiveness $E_t$is then calculated by comparing the risk from the unhedged position to the risk from the hedged position as in expression (4):

$$\mathrm{E}_t = 1 - \frac{Var(\Delta C_t^h)}{Var(\Delta C_t^u)} \qquad (4)$$

where $Var(\Delta C_t^h)$ is the conditional variance of the change in cash price from a hedged position, and $Var(\Delta C_t^u)$ is the conditional variance of the change in cash price from an unhedged position. E_t measures the percentage reduction in the conditional variance of the change in cash price when hedging occurs. In the presence of a hedge, the conditional variance of the change in cash price is given by the mean squared error (MSE) from (3). In the absence of a hedge, the conditional variance of the change in cash price is generated using the MSE from (2).

DATA

Daily futures and spot prices on live cattle were obtained from the Brazilian Securities, Commodities and Futures Exchange (BM&FBOVESPA)for the period March 1, 2001 to February 28, 2011. Both futures and spot prices are quoted in the Brazilian currency–Reals (R$)–per 15 kilograms.

Live cattle futures contracts on the BM&FBOVESPA are traded for each month of the year.The underlying commodity is an animal ready for slaughter with weight ranging between

450 and 550 kilograms. The futures contract size is 4,950 kilograms (330 units of 15kg), which corresponds to approximately 10 animals.The last trading day of a contract is the last business day of the maturity month. The nearby futures price is used in this study, and the series is rolled over to the next maturity on the last day of the contracts.

Spot prices refer tofour active spot markets in the state of São Paulo: Araçatuba, Presidente Prudente, Bauru/Marília, and São José do Rio Preto/Barretos (Appendix, Figure 4). They are all interior locations and have traditionally been important centers of cattle production. These four locations are used to calculate the average price adopted by BM&FBOVESPA to cash settle the futures contract. In addition, the delivery point specified in the futures contract is alivestock yard located in the city of Araçatuba.

RESULTS

Live cattle prices generally show a increasing trend during the sample period, with their lowest values around R$40/unit of 15kg observed in 2001 and their highest values close to R$115/unit of 15kg observed towards the end of 2010 (Table 1 and Appendix, Figure 5). Nearby futures prices and spot prices in all four regions exhibit similar distributional moments, with close values for means, standard deviations, skewness and kurtosis across all series (Table 1).

Table 1: Summary statistics – futures and spot prices (R$/unit of 15kg)

	Futures	Araçatuba	S.J. Rio Preto/Barretos	Bauru/ Marília	Presidente Prudente
Mean	63.67	62.29	62.49	62.55	62.68
Std. deviation	16.22	15.98	15.91	16.21	16.02
Skewness	0.75	0.78	0.78	0.78	0.79
Kurtosis	2.76	2.88	2.87	2.81	2.90
Minimum	39.30	38.71	38.81	38.70	38.42
Maximum	115.96	115.14	113.66	113.65	114.26
Observations	2,479	2,479	2,479	2,479	2,479

Prices are transformed to logarithmic form and the series are broken into two sub-periods: 2001-2006 and 2007-2011. These periods represent two distinct phases of futures market activity and are used to explore price discovery and risk transfer under low and high liquidity.[2]Unit root tests (Dickey-Fuller and Philips-Perron) are performed on all series and prices are found to be integrated of order 1. Johansen tests are then performed and futures and spot prices are found to be cointegrated in all spot market locations.

Error correction models (ECM) are estimated for both sub-periods with lag structured determined by BIC.Table 2 shows estimated coefficients of ECMs for all spot markets. Wald tests are performed with null hypotheses that all coefficients on the error correction term and lagged futures (spot) price changes are equal to zero when the change in spot (futures) price is the dependent variable. The null hypothesis in those tests is rejected at 5% in all models. Further, the error correction term (ECT) coefficient is found to be statistically distinguishable from zero

[2] Daily trading volume averaged 846 contracts in 2001-2006, and 4,032 contracts in 2007-2011.

in all equations (Table 2). These results support the notion that futures and spot markets are highly interactive in both periods.

Table 2: Estimated ECM for four Brazilian spot markets

	Araçatuba		S.J. Rio Preto/Barretos		Bauru/Marília		Presidente Prudente	
	2001-06	2007-11	2001-06	2007-11	2001-06	2007-11	2001-06	2007-11
Futures equation								
ECT_{t-1}	-0.03*	-0.04**	-0.03*	-0.04**	-0.02	-0.04***	-0.03**	-0.05***
Δfut_{t-1}	0.08***	0.07*	0.10***	0.05	0.09***	0.05	0.09***	0.08**
Δfut_{t-2}	0.03	0.05	0.05	0.03	0.06*	0.05	0.05*	0.06*
Δfut_{t-3}	0.01		0.02		0.02		0.01	
Δfut_{t-4}	-0.00		0.00		0.01		0.01	
Δfut_{t-5}	0.04		0.02		0.03		0.02	
$\Delta spot_{t-1}$	0.23***	0.17***	0.16***	0.29***	0.17***	0.30***	0.14***	0.16***
$\Delta spot_{t-2}$	0.08**	0.07*	0.08**	0.03	-0.00	-0.01	0.08***	0.10**
$\Delta spot_{t-3}$	0.04		0.03		-0.04		0.03	
$\Delta spot_{t-4}$	-0.05		-0.04		-0.00		0.02	
$\Delta spot_{t-5}$	-0.04		0.00		0.04		0.02	
constant	0.00	0.00*	0.00	0.00*	0.00	0.00	0.00	0.00*
Spot equation								
ECT_{t-1}	0.09***	0.10***	0.11***	0.10***	0.11***	0.08***	0.09**	0.13***
Δfut_{t-1}	0.09***	0.06***	0.06***	0.07***	0.05	0.05**	0.05***	0.07***
Δfut_{t-2}	0.06***	0.09***	0.07***	0.04*	0.07	0.05**	0.10***	0.03
Δfut_{t-3}	0.08***		0.08***		0.07		0.06***	
Δfut_{t-4}	0.03		0.06***		0.09		0.10***	
Δfut_{t-5}	0.06***		0.02		0.00		0.05***	
$\Delta spot_{t-1}$	-0.09***	-0.09***	-0.16***	-0.02	-0.18***	0.04	-0.20***	-0.21***
$\Delta spot_{t-2}$	0.04	0.07**	-0.02	0.06**	-0.03	0.10***	-0.02	0.04
$\Delta spot_{t-3}$	0.05*		0.04		0.04		0.01	
$\Delta spot_{t-4}$	0.01		0.02		-0.01		0.01	
$\Delta spot_{t-5}$	-0.01		0.07***		0.03		0.03	
constant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Obs.	1,450	1,029	1,450	1,029	1,450	1,029	1,450	1,029

***, **, * statistically distinguishable from zero at 1%, 5%, and 10%

The statistical significance of the ECT and its opposite signs in each equation suggests that both futures and spot markets adjust to shocks in the long-run equilibrium relationship (Table 2). Point estimates show little change across periods, and the magnitude of the ECTs suggests that spot prices adjust more rapidly than futures prices in both periods. However, the differences in the speed of adjustment in the spot and futures equations appear to narrow somewhat in the second period.

These findings in the long-run dimension differ from Mattos and Garcia (2006) who used live cattle prices from 2001 to 2003. They find the futures price was weakly exogenous and the spot price adjusted only modestly to the long-run equilibrium. In the current study there is evidence that both prices participate in the adjustment process, suggesting a stronger interaction between the two markets has developed since 2003. The closer connection between spot and futures markets is likely a general reflection of the increase in futures market activity over the last decade and the growing participation of meat packers who are heavily involved in both markets.

The statistical significance of lagged price changes in both equations also supports the notion of highly interactive markets in the short run (Table 2). The estimated coefficients of the lagged spot price changes in the futures equation are larger than the corresponding lagged futures price changes in the spot equation, suggesting spot market is more dominant in the short-run dynamics. In addition, estimated coefficients of lagged spot price changes often increased in the second period, while the ones on lagged futures price changes are almost the same in both periods. Finally, the lag structure in the second period as selected by the BIC shortens in all markets, indicating the transmission of information is taking place more rapidly. These findings appear consistent with the idea that spot market activity has been the driving force in the pricing process, with vast participation of packers using futures markets to hedge their trades in the spot market.

Despite the interactive nature of the markets and improved speed of price transmission, hedging opportunities remain limited and little effectiveness (Table 3). Estimated hedge ratios for all spot markets range between 0.12 and 0.18 in both periods, indicating little change as futures trading activity improved over time. Hedging effectiveness is below 0.10 in all cases, showing minor improvement in the second period and implying modest potential for reduction in the unconditional variance of spot prices. These results are in line with Mattos and Garcia (2006) who found hedge ratio of 0.07 and hedging effectiveness of 0.03 in 2001-2003, suggesting rising trading activity has barely had any effect on hedging prospects.

Table 3: Estimated hedge ratios and hedging effectiveness

	2001-06		2007-11	
	hedge ratio	hedging effectiveness	hedge ratio	hedging effectiveness
Araçatuba	0.149	0.06	0.178	0.06
S.J. Rio Preto/Barretos	0.124	0.03	0.172	0.06
Bauru/Marília	0.136	0.04	0.174	0.09
Presidente Prudente	0.163	0.04	0.180	0.05

CONCLUSION

This paper describes developments in the Brazilian live cattle market in the last 10 years and investigates their effects on futures market’s price discovery and risk transfer functions. The large growth in exports and domestic changes in the structure of the beef industry have motivated meat packers to participate increasingly in futures markets. The larger activity of packers in futures trading, along with specific delivery characteristics of the live cattle futures contract, has also led speculators to trade more actively. As a result, trading volume in the live cattle futures market has increased almost tenfold over the last decade.

The overall results show little evidence that the rising trading volume in futures market impacted appreciably price discovery and risk transfer. In 2001-2006 when futures trading volume was relatively low spot and futures prices already shared a long-run relationship, which continued to exist in 2007-2011 when futures trading volume became considerably large. However, it does appear that higher trading volume has modestly reinforced the long-run relationship between spot and futures markets, strengthened the role of futures market in the pricing process, and led to a more rapid transmission of market information between spot and futures markets. In terms of risk transfer, the results provide little evidence that the live cattle futures contract offers effective hedging opportunities, either under low or high trading volume.

The findings are consistent with previous studies in the sense that even low trading volume is enough to establish links between spot and futures markets. However, the absence of hedging opportunities when futures trading increases was somewhat surprising and raises questions. Perhaps, even larger increases in trading volume are needed to facilitate effective risk transfer. In a different context, the study investigated futures hedging using a daily horizon, which may not coincide with hedging horizons used by packers, the new participants on the short side of the market. Hedging analysis based on weekly or monthly horizons may be more consistent with actual industry hedging practices. Further, since hedgers are also exposed to exchange rate risk, they may not follow the risk-minimizing strategy for the live cattle price assumed here. Rather their actual hedging strategies may combine both price and exchange rate or even focus primarily on exchange rate, influencing hedge ratios for live cattle generated in this research. The answers to these implied questions await future research.

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APPENDIX

Figure 1: Meat exported by Brazilian meat packers (million of tons per year) – 1996 to 2009

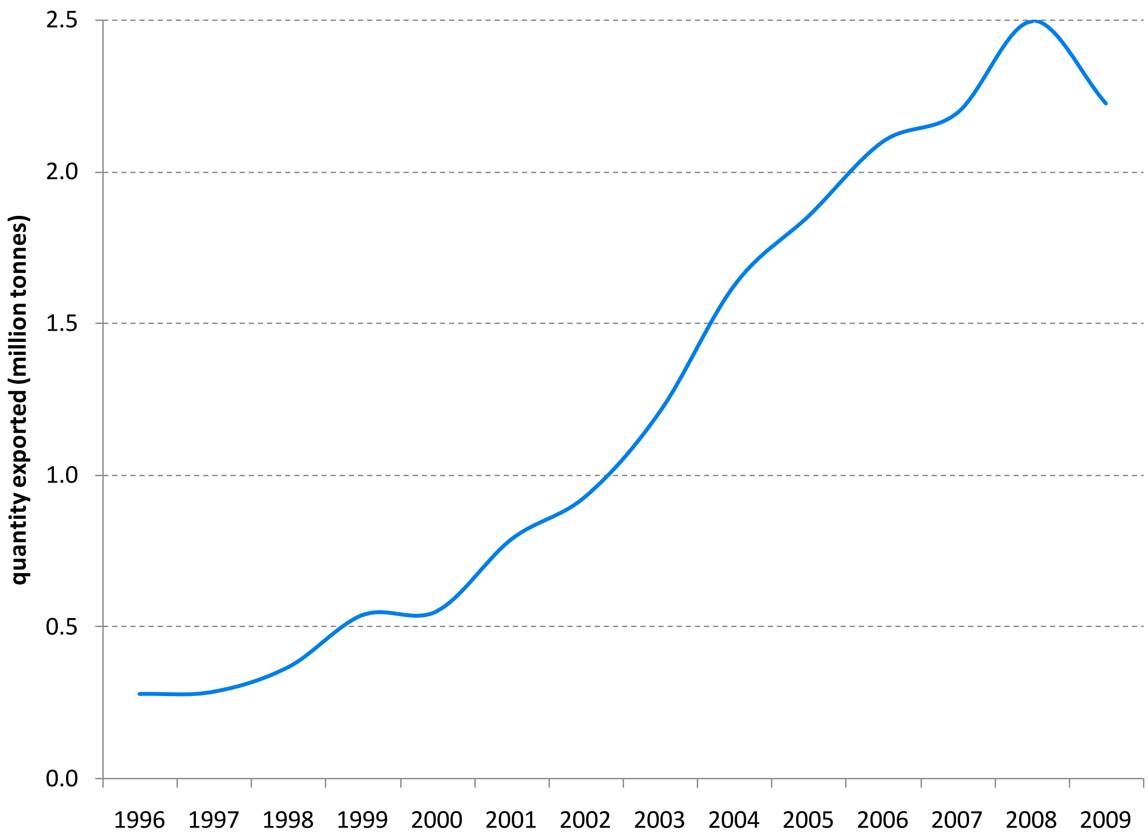

Figure 2: Daily trading volume in the Brazilian live cattle futures market

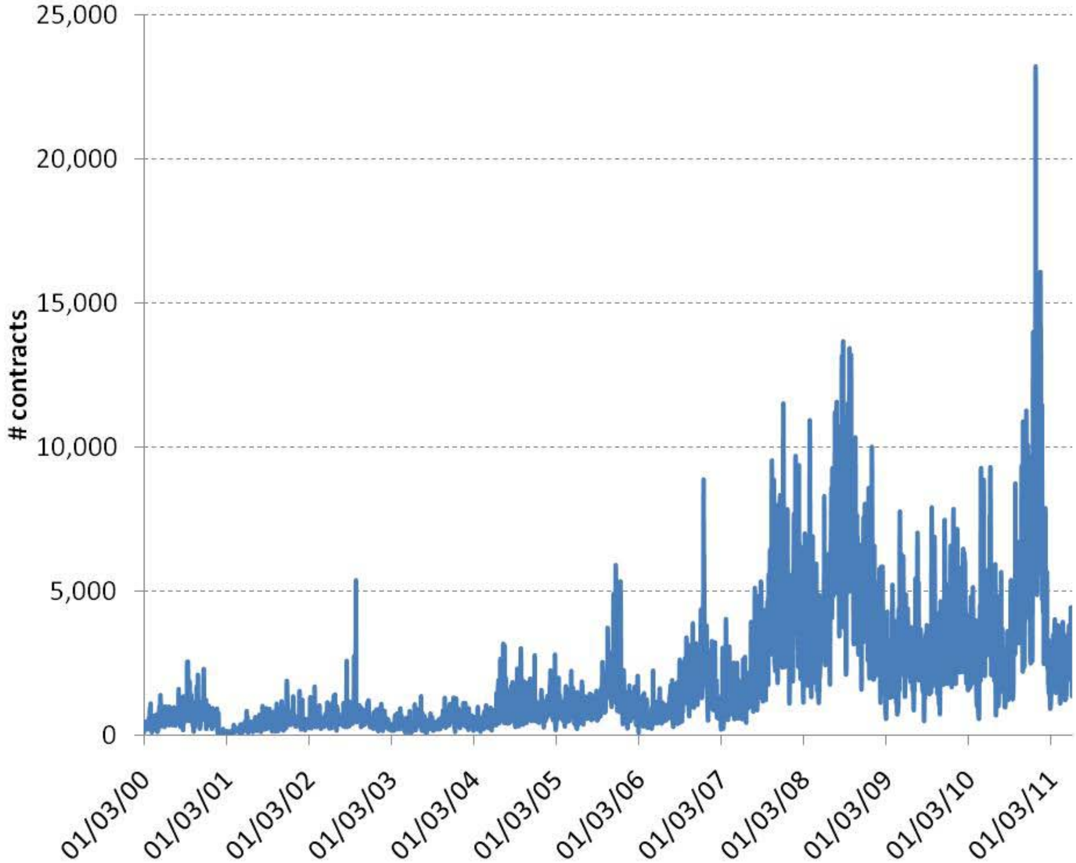

Figure 3: Daily open interest for short positions in the Brazilian live cattle futures market (1,000-day moving average)

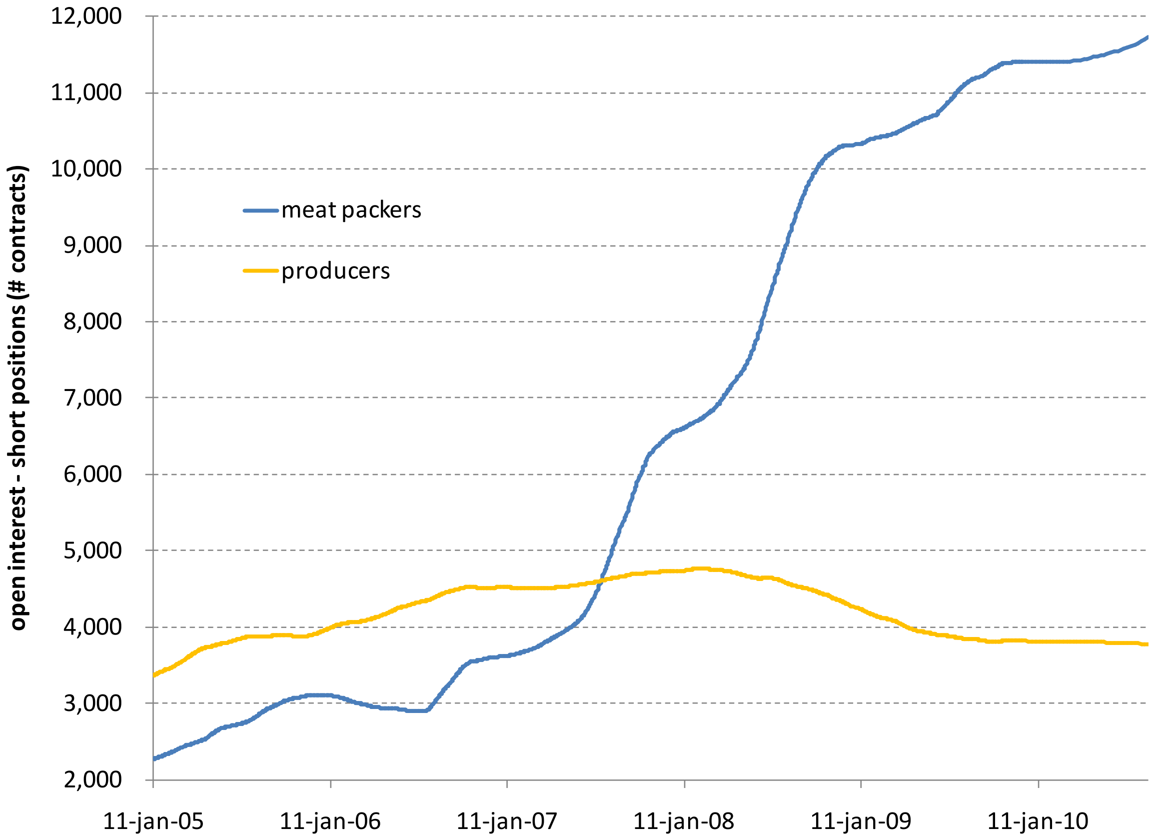

Figure 4: Map of state of São Paulo highlighting four live cattle spot markets

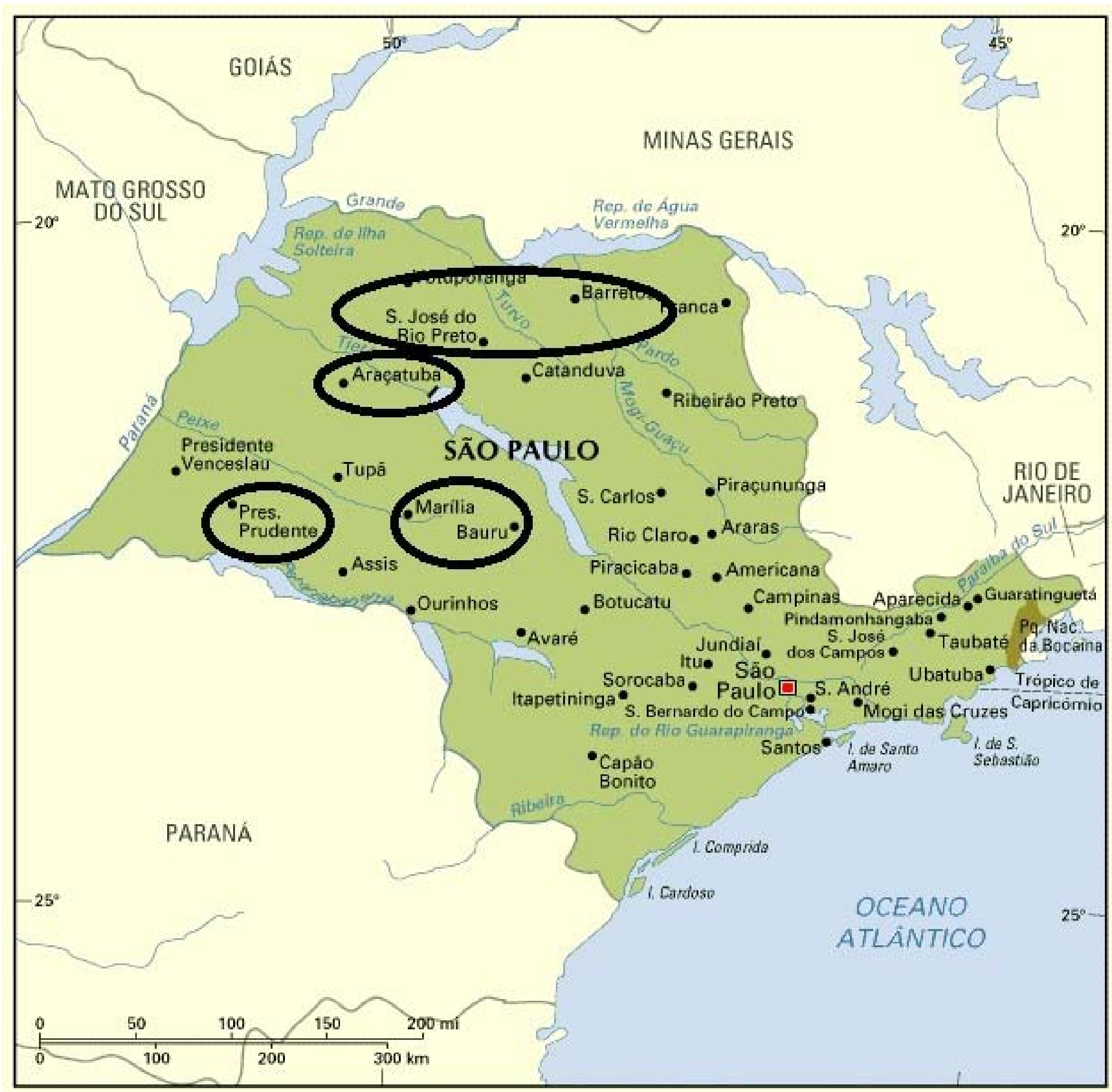

Figure 5: Live cattle spot prices in Brazilian markets from March/2001 to February/2011 (R$/unit of 15kg)